Art. III.—*On a Modification of Mance's Method of Measuring the Resistance of a Battery.*

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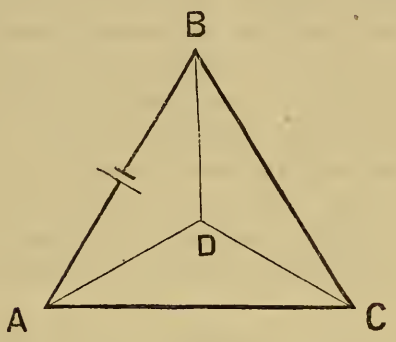

Mance's method of measuring the resistance of a battery is based on the following proposition :—

Let A, B, C, D be four points connected by six conductors, as in the figure, a battery being in he branch AB.

Then, if the resistance of AB is to that of BC as the resistance of AD is to that of DC, the current in AC will be independent of the resistance of BD ; and, *vice versâ*, if the current in AC is independent of the resistance of BD, the above relation exists between the resistances of AB, BC, AD, DC.

If, then, we adjust the resistances of BC, AD, and DC until the current in AC is unaffected by varying the resistance of BD, and if we know the resistance of BC and the ratio of the resistance of AD to that of DC, the resistance of AB is found by a simple calculation.

In the method as originally proposed, a galvanometer is placed in AC, and a key in BD ; and the resistances of BC, AD, and DC are adjusted until no alteration in the deflection of the galvanometer is produced by making and breaking contact by means of the key.

In this application of the principle the greatest sensitiveness is obtained when the resistance of AD is equal to that of DC, and the resistances of ADC and AC are equal, and as small as possible.

Dr. Lodge, in a very valuable and interesting paper, published in the *Philosophical Magazine* for June, 1877, has pointed out two defects in this method.

1. The balance of resistances being tested by the *variation* of the current in AC, which will be small compared with the current itself when the balance is nearly obtained, a sensitive galvanometer cannot be employed; and even the sensitiveness of the coarse galvanometer generally used has to be diminished by the intensification of the magnetic field in which its needle moves, caused by the external magnets used to bring the needle near its zero position.

2. Although, when the resistances are balanced, altering the resistance of BD does not directly change the current in AC, it does change the current in AB. Now the electromotive force of a battery does, to some extent, depend upon the strength of the current passing through it, so that if the resistance in BD is altered the change in the electromotive force of the battery thereby produced will alter the current in AC.

In some cases the resistance of AB will also vary with the strength of current passing through it. Dr. Lodge, in his paper, says that if the resistance of a conductor depends on the strength of the current passing through it, the resistance is not a definite magnitude, and cannot be measured. I would, however, point out that, while Ohm's law no doubt implies that the resistance of a conductor is a fixed quantity independent of the strength of current passing through it, yet changing the strength of the current may produce a change in the conductor itself (as in the temperature of a wire, the chemical composition of the parts of a voltaic battery, the size and temperature of an electric arc), whereby its resistance is altered. I imagine that it is in this indirect way that change of current strength affects electromotive force.

Dr. Lodge, in the paper above referred to, describes a modification of Mance's method, which consists in introducing a condenser in the branch AC, and employing a special form of key whereby contact in BD is made for but a very small portion of time.

In order to obtain the greatest sensitiveness, the resistances of AD and DC should be as great as possible, and the resistance of the galvanometer and capacity of the condenser also great.

Now, if we make the resistance of ADC large compared with that of AB, the current in AB will be small compared with the greatest current which the battery can produce. Hence Lodge's method, although very valuable for many purposes, seems unsuited for measuring the resistance of a battery when producing a current of magnitude comparable with that which passes through it when short-circuited.

The method which I submit to your notice this evening consists in replacing the galvanometer used in Mance's method by the primary wire of a small induction coil, with the secondary wire of which a telephone is connected. Contact in BD is alternately made and broken rapidly by a vibrating spring, kept in motion by an electro-magnetic arrangement worked by a separate battery, or by the current in BD itself, if none of the branches have sensible coefficients of self-induction, or the resistance of BD is slightly varied by introducing into it a microphone, on the stand of which a small clock is placed. By either of these methods we may produce periodic changes in the resistance of BD, and make these changes so small that the resistance and electro-motive force of AB will be practically constant. Although the changes in the strength of the current in AC will also be slight, yet the telephone will detect alterations which could not be rendered evident by galvanometric methods.

The modification of Mance's method which I propose seems to possess the two following advantages :—

1. It enables us to measure the resistance of AB when a powerful current is passing through it.

2. In its employment the strength of current in AB need be but slightly affected.

For these reasons it appears to me especially suited for measuring the resistance of an electric arc, the lamp being introduced in the branch AB, the joint resistance of the battery (or machine) and lamp measured, and the resistance of machine, lamp fittings, and carbons separately ascertained.